SAIL: Salmon and Sturgeon Assessment of Indicators by Life stage

Opportunities for Improved Fisheries Management in the San Francisco Estuary Watershed Through Life Stage Monitoring:

Endangered Sacramento River Winter-run Chinook Salmon

Southern DPS of N. American Green Sturgeon & Sacramento-San Joaquin White Sturgeon

Team Leads: Dr. Rachel Johnson & Joe Heublein

IEP Directors' charge: To analyze and synthesize existing information and to provide a focused *framework* for *salmon & sturgeon monitoring* and targeted studies, in the Delta and Sacramento River, with high potential to inform management decisions (NMFS BiOp, Recovery Plans, etc.).

Interagency Ecological Program
Cooperative Ecological Investigations Since 1970

Increasing the management value of life stage monitoring networks for three imperiled fishes in California's regulated rivers:

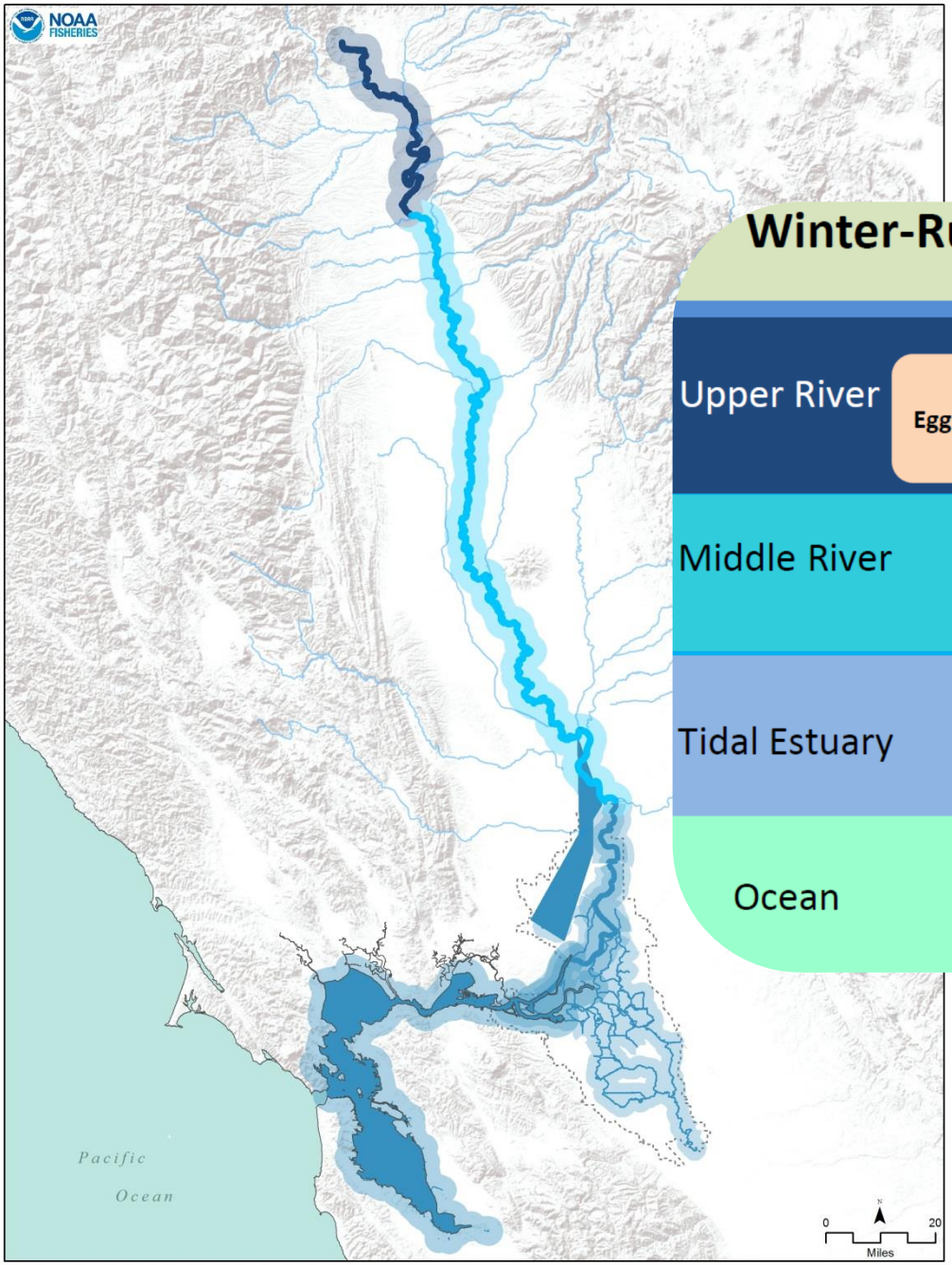
Case study Sacramento Winter-run Chinook Salmon

Rachel C. Johnson (NMFS/SWFSC), Sean Windell (DSP), Patricia Brandes (USFWS), J. Louise Conrad (DWR), John Ferguson (Anchor QEA), Pascale Goertler (DWR), Brett Harvey (DWR), Joseph Heublein (NMFS/CCAO), Joshua A. Israel (USBR), Joseph Kirsch (USFWS), Todd Miller (USFWS), Russell Perry (USGS), Joseph Pisciotto (CDFW), William R. Poytress (USFWS), Kevin Reece (DWR), and Brycen Swart (NMFS/CCAO)

Case study Southern DPS of N. American Green Sturgeon and Sacramento-San Joaquin River White Sturgeon

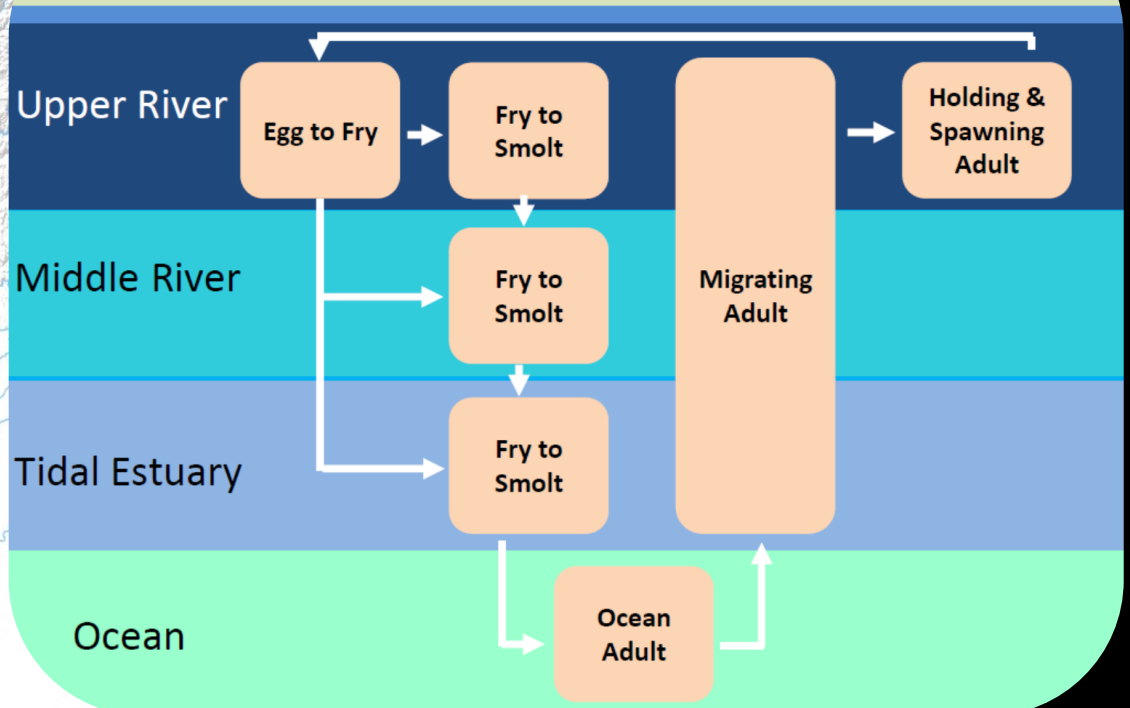
Joseph Heublein (NMFS), Russ Bellmer (CDFW), Robert Chase (USACE), Phaedra Doukakis-Leslie (NMFS), Marty Gingras (CDFW), Douglas Hampton (NMFS), Joshua Israel (USBR), Zachary Jackson (USFWS), Rachel Johnson (NMFS), Olaf Langness (WDFW), Sean Luis (NOAA Corps),
Ethan Mora (NMFS/SWFSC), Mary Moser (NMFS/NWFSC), Larissa Rohrbach (Anchor QEA), Alicia Seesholtz (DWR), Ted Sommer (DWR), and Jeffrey Stuart (NMFS)

Sub-model Framework



Winter-Run Life-Cycle Conceptual Model

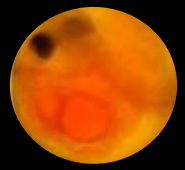
Sub-Model Map



Tier 5: Location

Upper River

Egg



Fry Emergence

Abundance, Survival, Timing, Condition

Tier 4: Responses

Tier 3: Habitat Attributes

In-river Fishery/ Trampling H_1

Toxicity/ Contaminants H_2

Redd Quality H_3

Stranding/ Dewatering H_4

DO H_5

Pathogens/ Disease H_6

Water Temperature H_7

Substrate size H_8

Predation Risk H_9

Tier 2: Environmental Drivers

Regulations/ Enforcement

Contaminant Loading

Depth

Keswick Releases/ Flows

Air Temperature

Mobilized Substrate

Tier 1: Landscape Attributes

Proximity to Contaminant Discharge

Bathymetry

Shasta & Trinity Storage/ Hydrology

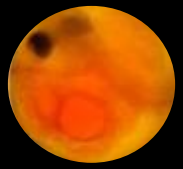
Climate

Erodible Sediment Supply

Tier 5: Location

Upper River

Egg

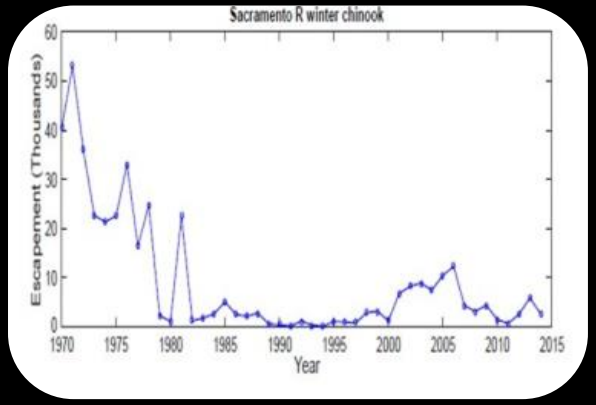


Fry

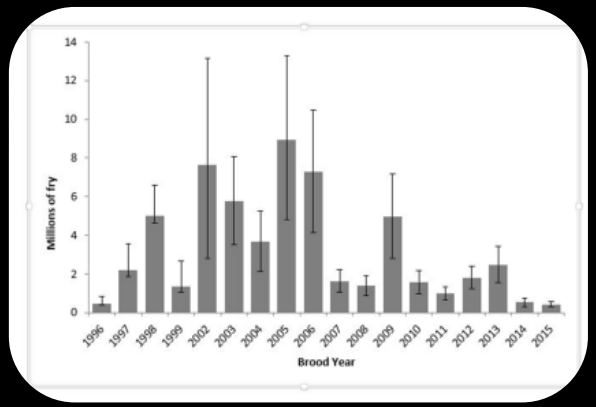
Tier 4: Responses

Abundance, Survival, Timing, Condition

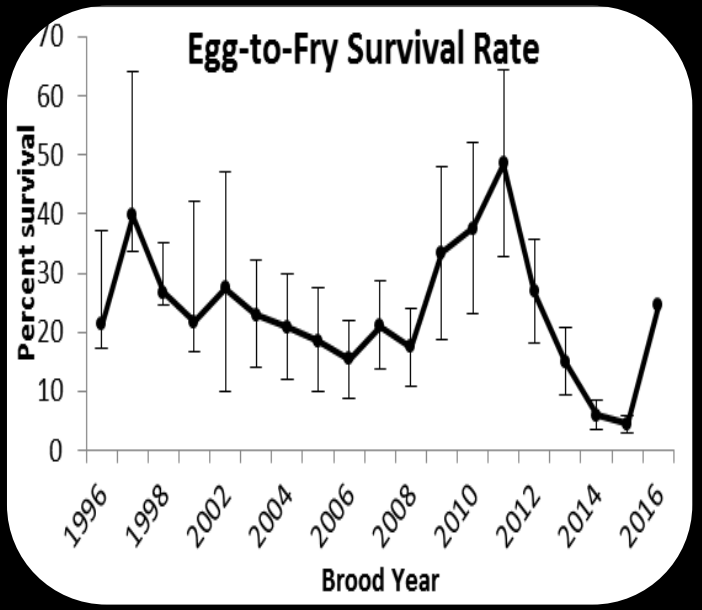
Mark-recapture Carcass Survey



Red Bluff Diversion Dam RSTs



=



Data sources: Killam et al. 2015, Poytress 2016, Johnson & Lindley 2016

69°
Sign In | Subscribe
THE SACRAMENTO BEE

WATER & DROUGHT OCTOBER 28, 2015 9:42 AM

Feds: Winter salmon run nearly extinguished in California drought

"We try to be hopeful, but this is not good news," said Maria Rea, the agency's assistant regional manager, in a conference call with reporters.

Federal officials sharply curtailed flows of water coming out of Lake Shasta this spring, delaying deliveries of irrigation water to hundreds of Central Valley farmers. Some who already had planted crops had to scrounge for water; others fallowed fields or saw smaller yields.

It now appears to have been a futile effort to keep enough cold water in the system to keep as many of the fish alive as possible.

If the preliminary figures are confirmed, it would be the second year running that nearly all of the juvenile winter-run Chinook succumbed because the water in the Sacramento River got too warm. Officials estimate that last year, only 5 percent survived long enough to migrate out to sea.

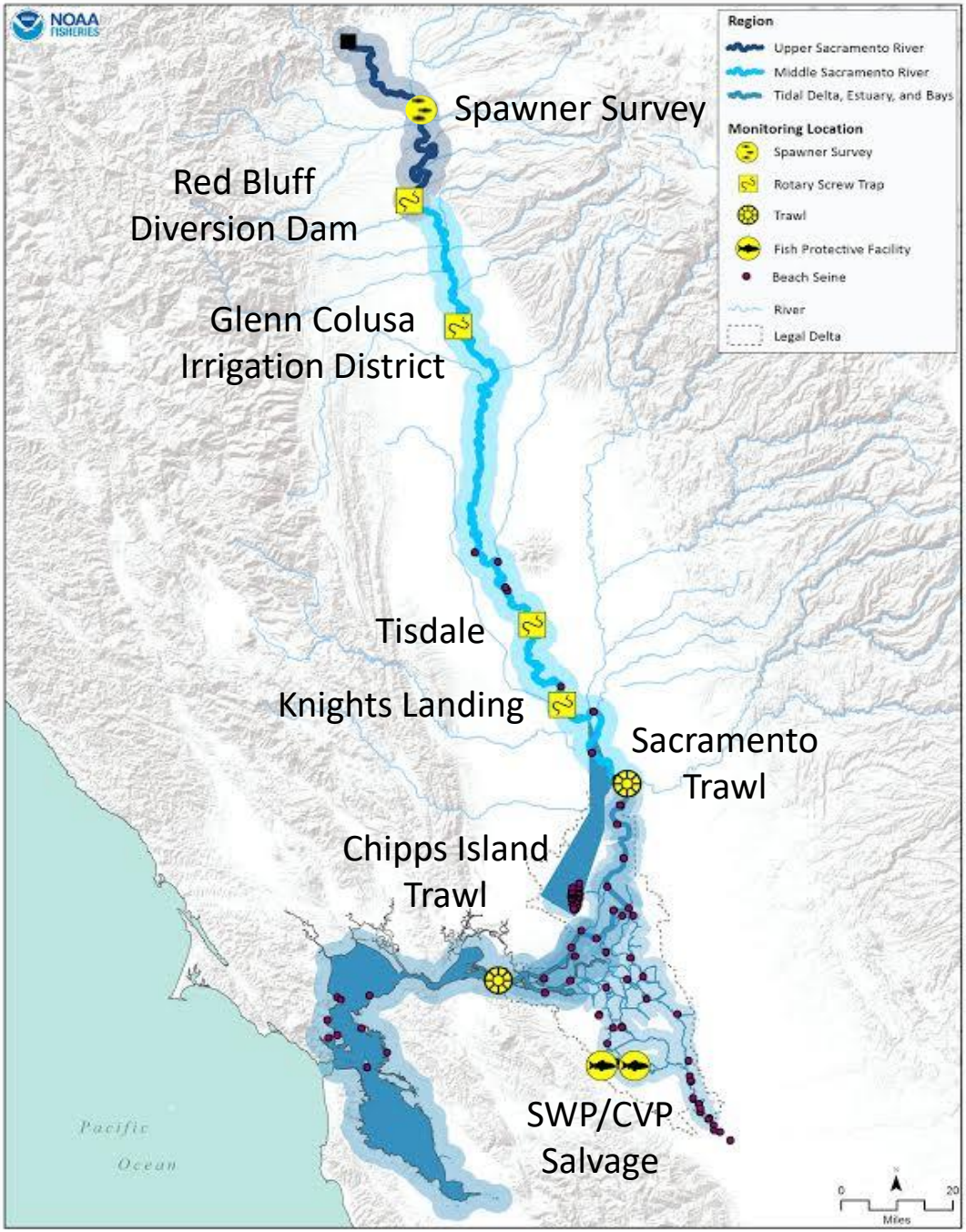
Preliminary counts indicate this year's situation is worse, Rea said. What's particularly troubling is that a higher number of adult fish actually swam up the river to spawn compared to last year, raising hope that the population of offspring heading downstream toward the Pacific would be greater.

Instead, Rea said, fish traps that biologists use to count young Chinook near Red Bluff have seen a nearly 22 percent drop from the same time last year.

Salmon dropoff at Red Bluff

The number of Sacramento River winter-run Chinook salmon juveniles swimming to the sea has dramatically declined in recent years.

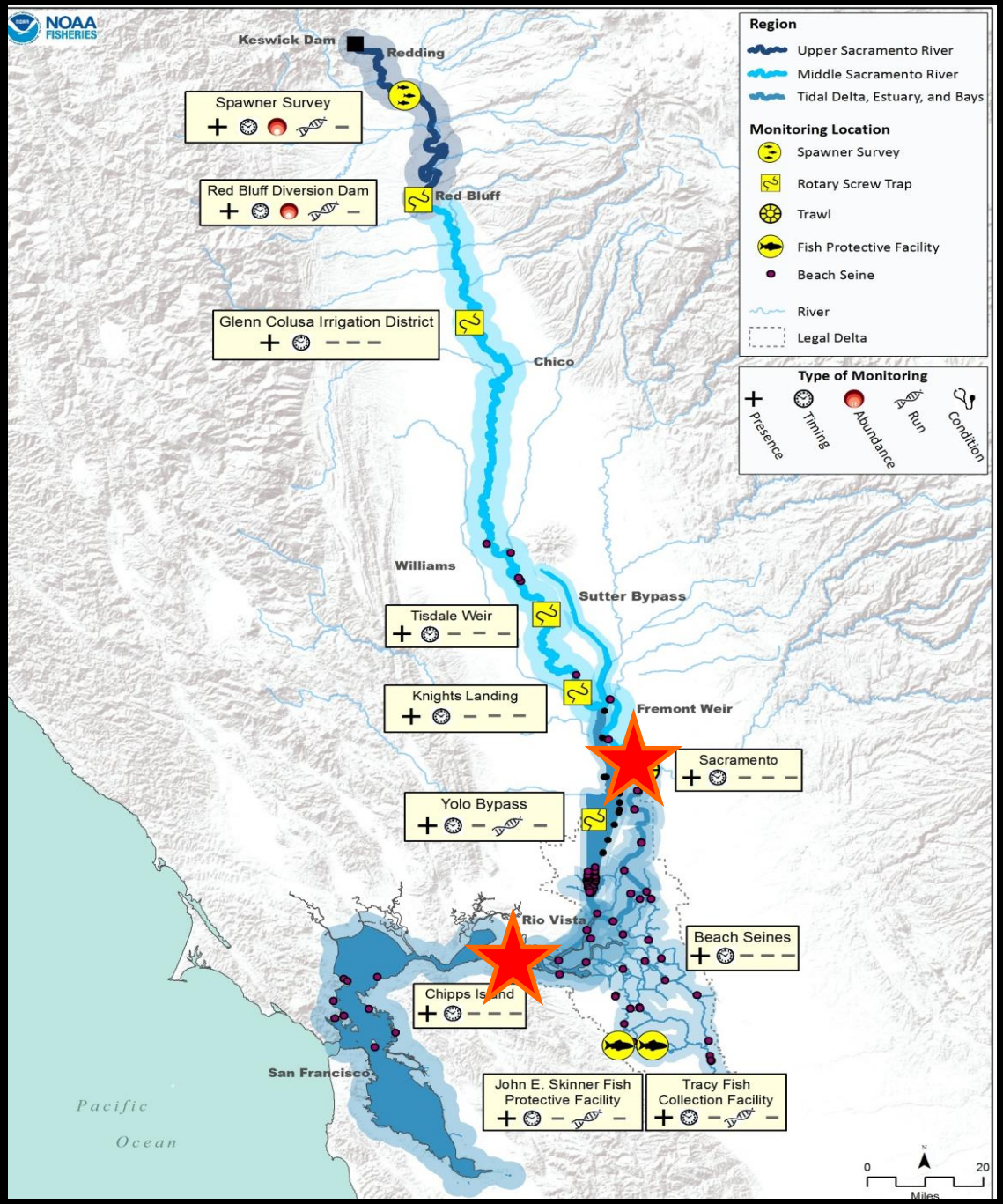
Through Oct. 21 After Oct. 21



Winter-run Monitoring Network

Tier 4: Fish responses

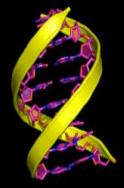
- Presence
- Timing
- Abundance
- Run Identification
- Condition



Winter-run Monitoring Inventory

6 System-wide Recommendations

1) Genetic run ID



2) Abundance

3) Survival

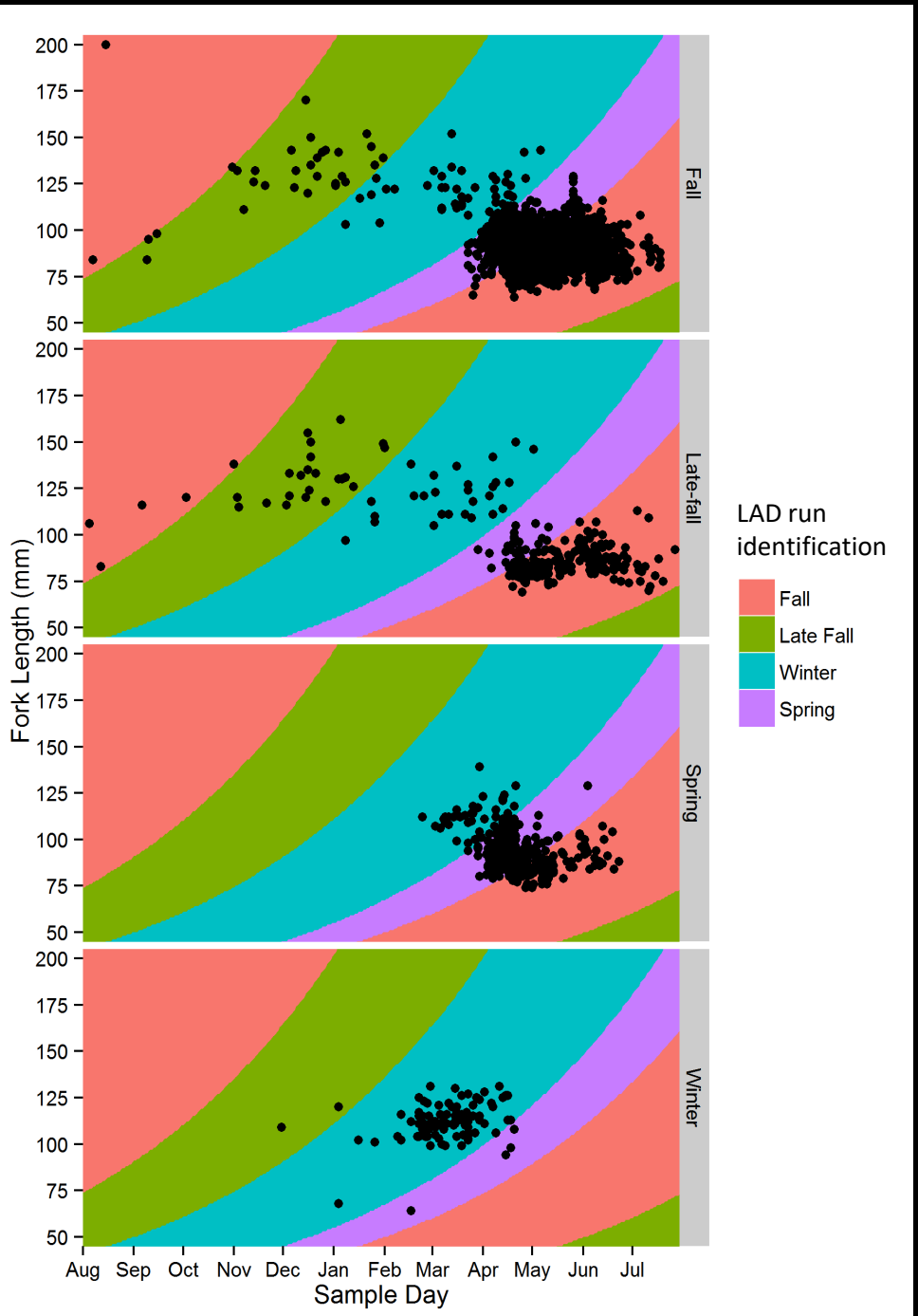
4) Diversity

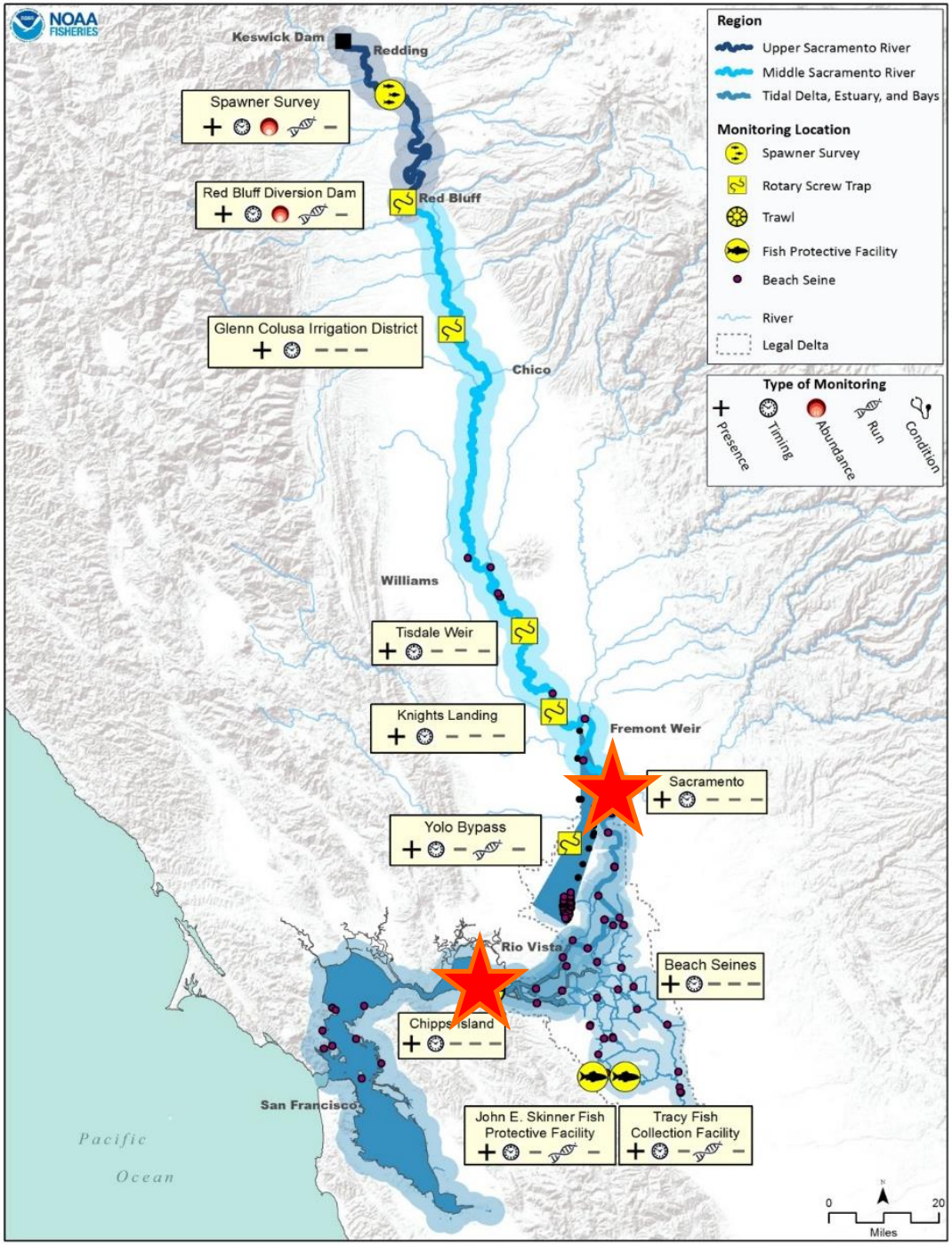
5) Condition

6) Data access

Advancement #1: Genetic ID

- **3** of **44** winter-run sized fish were true genetic winter run exiting Delta in 2016
- Overestimating winter run movements through the Delta
- Large effects on our understanding of the influence of water project operations.



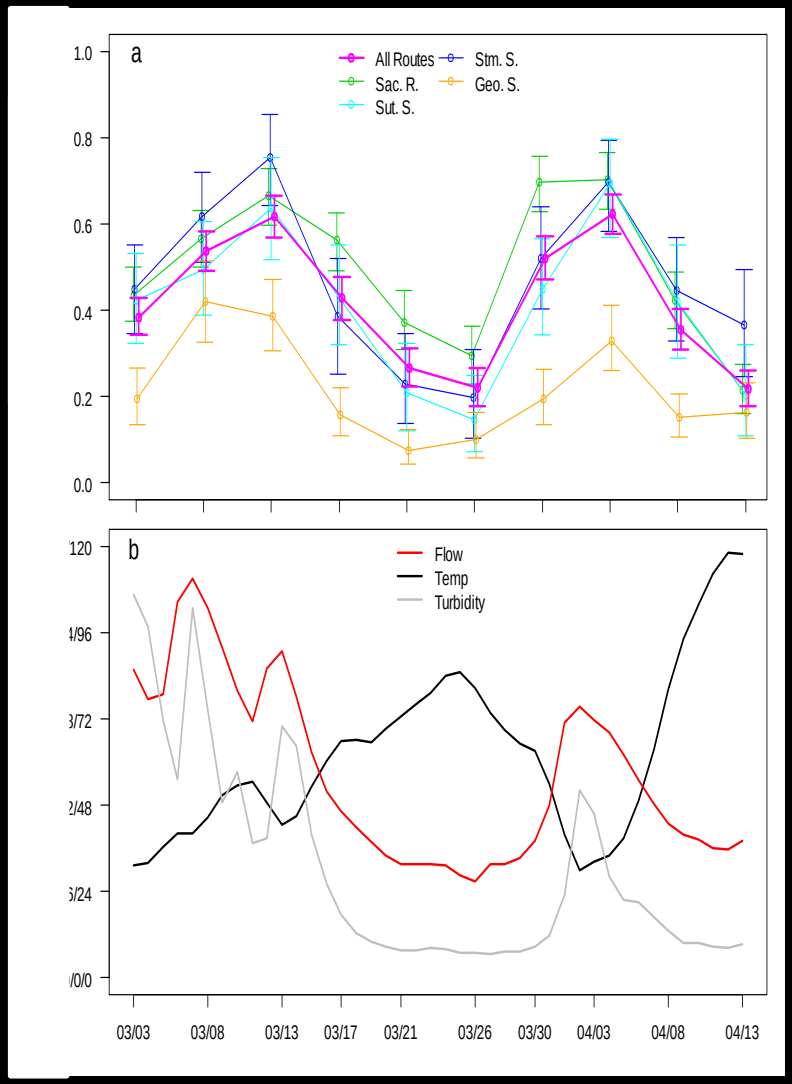


Advancement #2: Abundance

- Quantitative estimates at ecologically & management-relevant locations
- Gear efficiency estimates expand raw catches to population estimates
- Delta entry and exit
- Disentangle freshwater from marine mortality

Russ Perry: "A Hybrid Study Design Combining Acoustic Telemetry & Coded Wire Tagging to Estimate Trawl Efficiency & Run-Specific Abundance of Juvenile Salmon Entering and Exiting the Delta"

Advancement #3: Enhanced real-time acoustic telemetry network



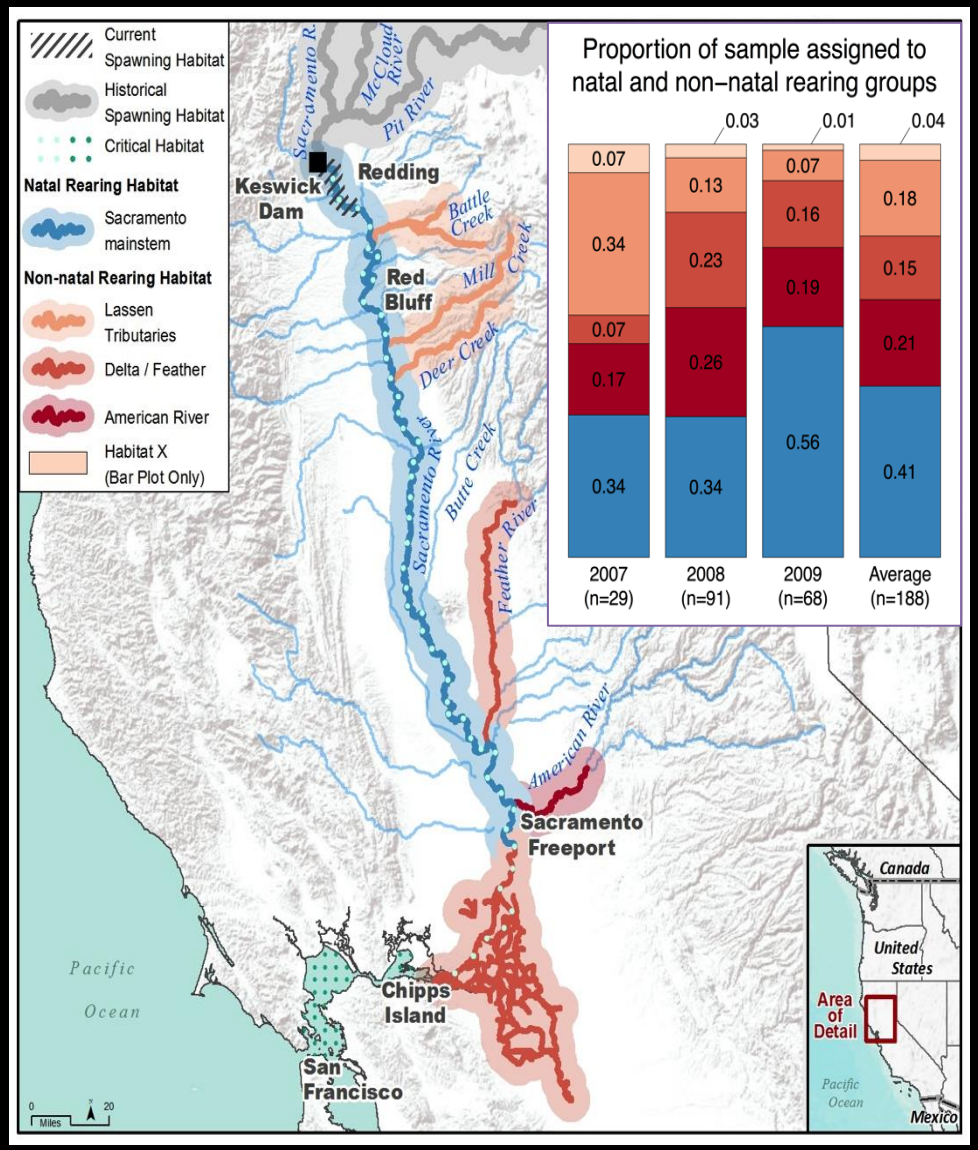
- System-wide, real-time core acoustic array linked to WQ
- Improve understanding where fish are in the system
- Operational flexibility
- Representative populations
- Establish & measure ‘survival standard’
- Annual reach-specific and system-wide survival

Data courtesy of R. Perry (USGS) and DWR

Jon Burau (USGS)- DREAMS- Delta Real-time Enhanced Acoustic Monitoring Stations

Advancement #4:
Behavioral and genetic diversity at multiple life stages

Juvenile rearing habitat diversity



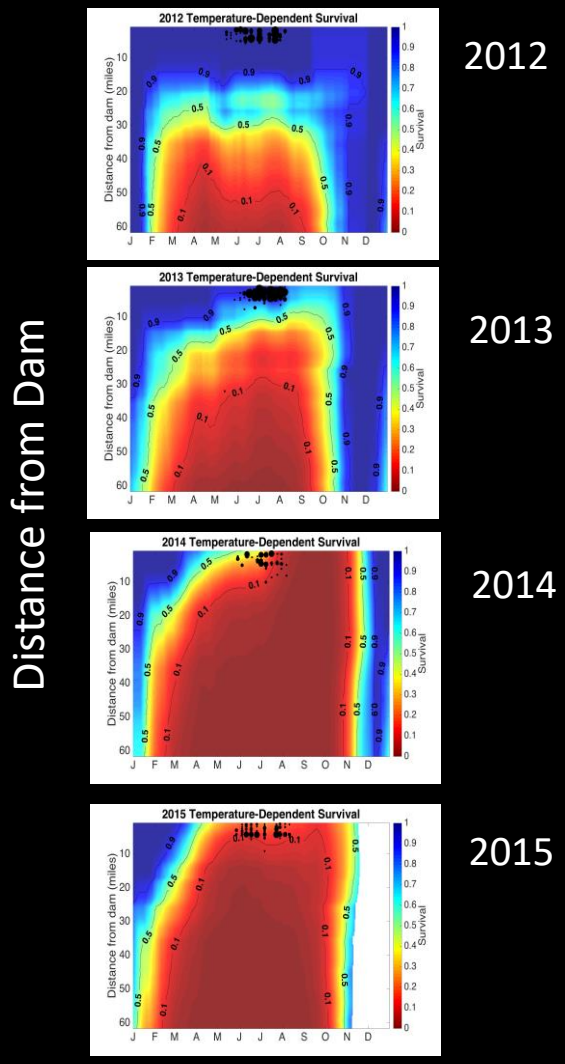
Phillis et al. , unpublished

Advancement #4:
Behavioral and genetic diversity at multiple life stages

Parentage Based Tagging

- Tissue library of adults [and juveniles]
- Link individuals to specific parents
- Monitor how many parents contributed progeny in a given year (Ne)
- Evaluate how adult spawn timing, location, origin (hatchery or wild), and water operations influence reproductive success

Survival landscapes



2012

2013

2014

2015

Distance from Dam

Months

RAFT model Pike et al. 2013

Advancement #5: Condition

Pathogen monitoring, stress markers, infection, and predation risk

Photo S. Foott USFWS

- 86% and 94% sentinel late-fall infected in 2015 (S. Foott)

Delta rearing and growth

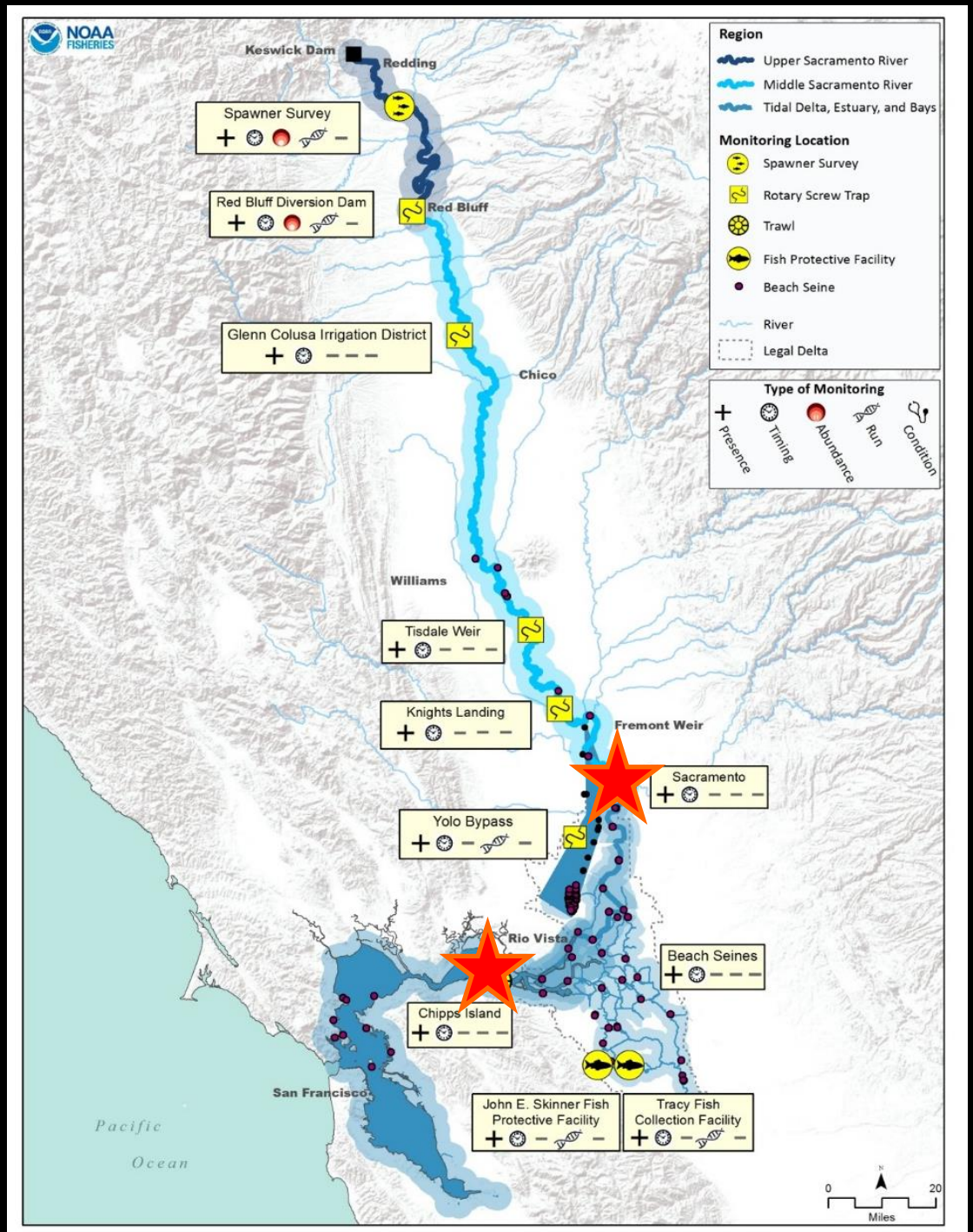
Photo courtesy of C. Jeffres UCD

- Only 4 days difference in age
- Freshwater growth & condition influences early ocean survival (Woodson et al 2013)

Advancement #6: Data Access

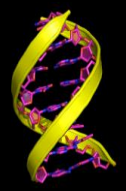
Life stage	Location	Open data available via website	Data storage locations	On-line annual reports
Upper River				
Adults	Upper River	No[1,2]	CDFW Red Bluff	Yes[3]
Adults (broodstock)	Livingston Stone National Fish Hatchery (Keswick Dam)	No	USFWS Red Bluff	Yes
Juveniles	RBDD	Yes[4]	USFWS Red Bluff	Yes[5]
Middle River				
Juveniles	GCID	No[6]	GCID	No
	Tisdale	No[7]	CDFW Rancho Cordova	No
	Knights Landing	No[8]	CDFW Rancho Cordova	No
	Yolo Bypass	No[8]	DWR West Sacramento	No
Tidal Estuary				
Juveniles	Sacramento	Yes[9]	USFWS Lodi	No[10]
	Delta	Yes[10]	USFWS Lodi	No[11]
	Chipps Island	Yes[10]	USFWS Lodi	No[11]
	Fish Protective Facility	Yes[11]	CDFW Stockton	Yes[12]
Ocean				
Hatchery Adults	Ocean fishery	Yes[13]	CDFW Santa Rosa	No
Multiple regions				
Hatchery Juveniles (survival)	Multiple regions (acoustic receivers)	No[14]	NMFS Santa Cruz	No
Migrating adults	Flood bypasses	No[15]	CDFW Sacramento	Yes[16]

Josh Israel: ”SacPAS: Sacramento Prediction and Assessment of Salmon through Ecological Data and Modeling for In-Season Management”



Winter-run Monitoring Network

1) Genetic run ID



2) Abundance

3) Survival

4) Diversity

5) Condition

6) Data access

Sturgeon team objectives

1. Identify key questions in sturgeon management
2. Determine the extent and performance of the existing monitoring enterprise
3. Develop conceptual models illustrating potential studies that address outstanding questions
4. Provide general monitoring study recommendations based on #1,2, and 3

1. Sturgeon management questions

Population status & trends

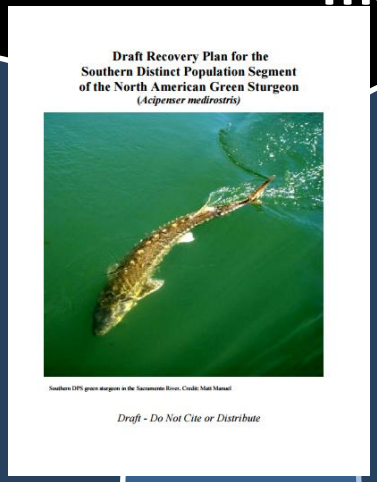
Mechanistic studies for management actions

Anglers Urged to Return Overdue 2015 Sturgeon Fishing Report Cards

MARCH 14, 2016

The California Department of Fish and Wildlife (CDFW) is reminding sturgeon anglers to return their 2015 Sturgeon Fishing Report Cards as required by law. Although the deadline to report their catch was Jan. 31, so far only about 13,000 (or 27 percent) of the 48,338 report cards sold have been returned. The sport fishing regulations require that all sturgeon anglers return their report cards, even those who did not encounter sturgeon and who did not fish for white sturgeon.

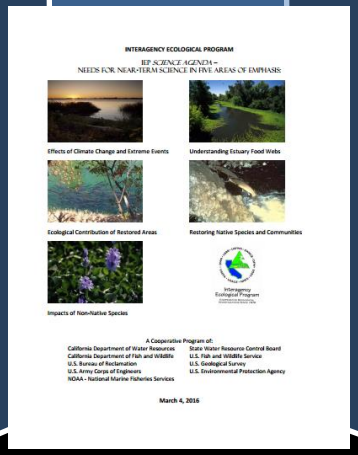
48,338 report cards sold



Draft Recovery Plan for the Southern Distinct Population Segment of the North American Green Sturgeon (*Acipenser medirostris*)

Southern DPS green sturgeon in the Sacramento River. Credit: Matt Manuel

Draft - Do Not Cite or Distribute



INTERAGENCY ECOLOGICAL PROGRAM

IEP SCIENCE AGENDA – NEEDS FOR NEAR-TERM SCIENCE IN FIVE AREAS OF EMPHASIS

Effects of Climate Change and Extreme Events

Understanding Estuary Food Webs

Ecological Contribution of Restored Areas

Restoring Native Species and Communities

Impacts of Non-Native Species

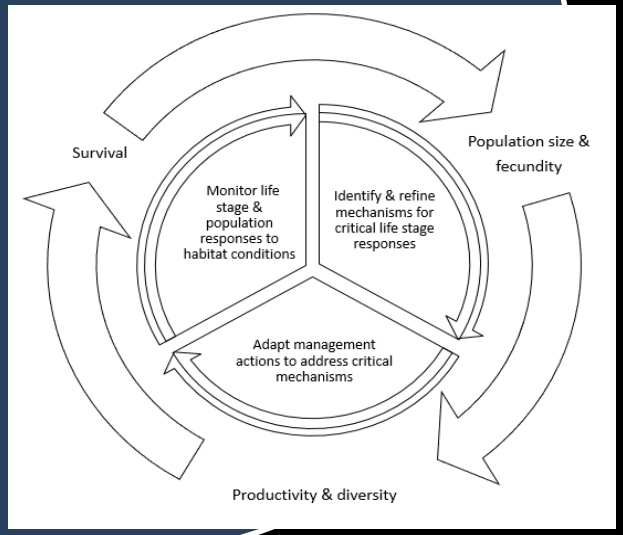
A Cooperative Program of:

California Department of Water Resources
California Department of Fish and Wildlife
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers
NOAA - National Marine Fisheries Services
State Water Resource Control Board
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency

March 4, 2016

CALIFORNIA WATERFIX

RELIABLE. CLEAN. WATER.



Monitoring categories

Population status & trends

Mechanistic studies

- Life stage surveys
- Tissue analyses
- Population modeling
- Telemetry

Photo USFWS

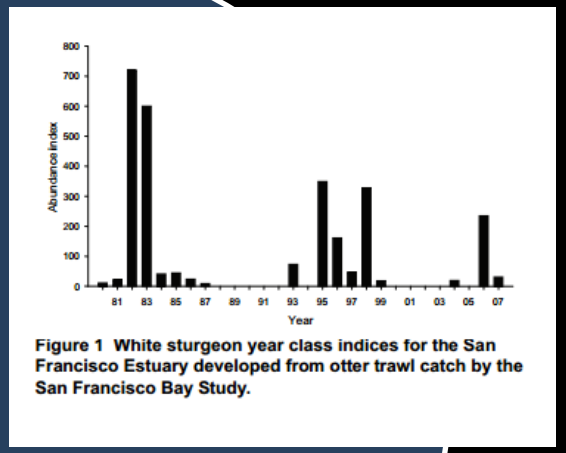


Figure 1 White sturgeon year class indices for the San Francisco Estuary developed from otter trawl catch by the San Francisco Bay Study.

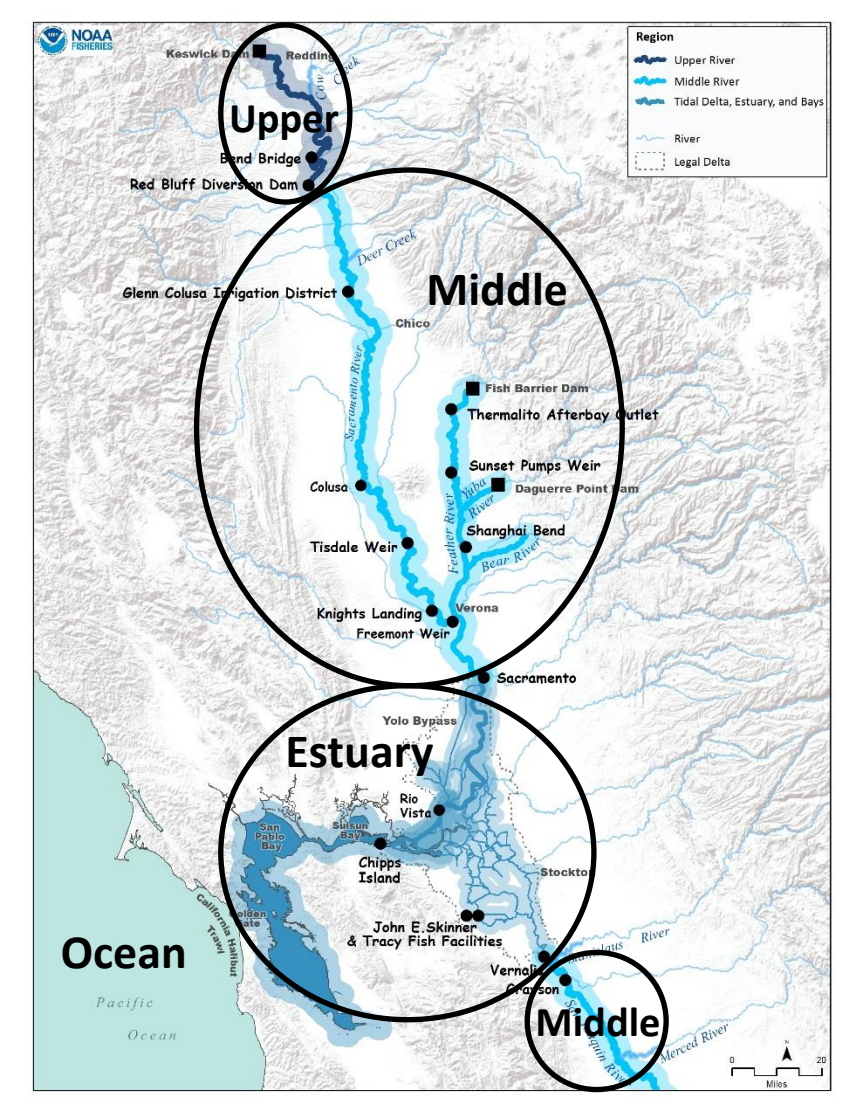
Figure Fish 2010

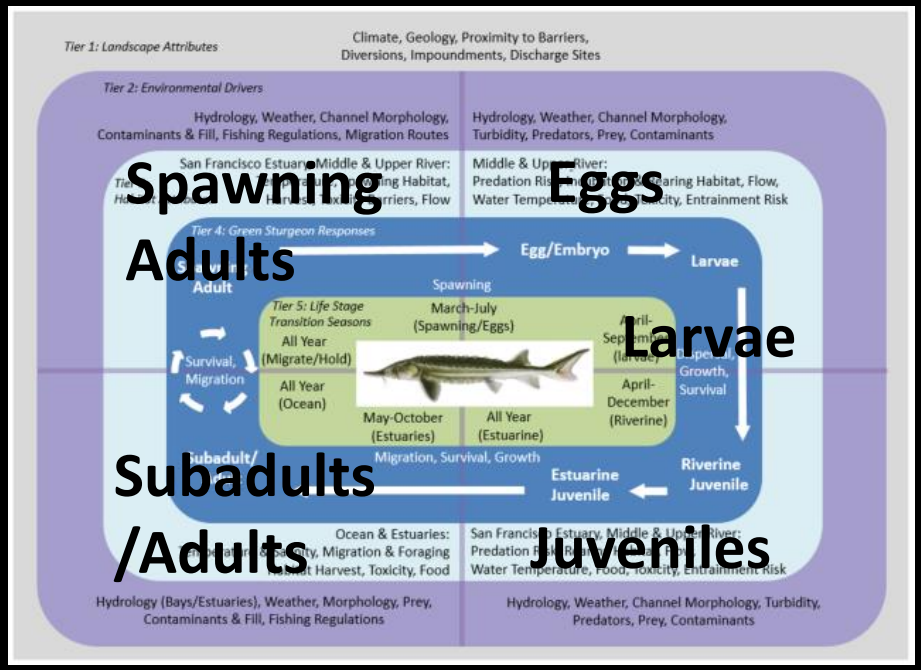
2. Green and white sturgeon monitoring inventories

Green Sturgeon	Eggs	Larvae	Juveniles	Subadults/Adults	Spawning Adults
Life stage surveys	• Sacramento River rotary screw trap collections at RBDD (2016;USFWS) • intermittent egg mat surveys on the Feather River (DWR) • habitat mapping of past egg collection sites and putative spawning areas on the Sacramento River (USFWS)	• Sacramento River rotary screw trap collections at RBDD (USFWS) and GCID (GCID) • intermittent larval D-netting on Sacramento River (USFWS) and Feather River (DWR)	• benthic trawl surveys near RBDD (USFWS) • Sturgeon Fishing Report Cards (location and length; CDFW) • intermittent collection in Bay Study (Delta; CDFW) intermittent salvage at the federal and state Delta pumping facilities (DWR;BOR)	• Sturgeon Study (trammel netting in Bay), Sturgeon Fishing Report Cards, boat logs, creel surveys (CDFW) • bycatch in California halibut trawl fishery (NMFS; CDFW) • intermittent sampling in San Pablo Bay, Columbia River, Grays Harbor, and Willapa Bay (UCD;WDFW; NMFS)	• DIDSON surveys in spawning habitat (NMFS;CDFW;DWR) • hook and line sampling in Feather River (DWR) • Sturgeon Fishing Report Cards, creel surveys (CDFW) • Yolo Bypass and Knights Landing fyke traps, stranding at Fremont and Tisdale weirs (DWR;CDFW)
Tissue analyses		• analysis of larval development (spawn timing; UCD)	• genetic analysis of benthic trawl samples (NMFS)	• fin ray analysis from Sturgeon Study (age; USFWS) • genetic analysis of California halibut fishery bycatch (NMFS)	• reproductive stage of sturgeon stranded at Fremont and Tisdale weirs (CDFW;UCD)
Telemetry			• lower Sacramento River monitoring (primarily gill-netting) for acoustic tag implantation (CDFW;UCD)	• satellite tagging of bycatch in California halibut trawl fishery (NMFS;CDFW); • detection of previously tagged fish in existing acoustic arrays (UCD;NMFS)	• detection of previously tagged adults in acoustic array (NMFS;WDFW;UCD;DWR) • acoustic tagging of sturgeon stranded a Fremont and Tisdale weirs (CDFW;UCD) • acoustic tagging of hook and line capture of adults in Feather River (DWR)
Population modeling and synthesis		• comparison of RBDD larval timing and abundance and environmental conditions (USFWS)	• hind-cast of recruitment success through estimated age of collected and reported juveniles (CDFW)		• modeling of run size using DIDSON and acoustic detection data, expansion of run size estimates to adult abundance estimates with spawning periodicity (NMFS)

White Sturgeon	Eggs	Larvae	Juveniles	Adults	Spawning Adults
Life stage surveys	• egg mat surveys, habitat mapping (San Joaquin River; USFWS)	• larval D-netting (San Joaquin River; USFWS) • 20mm Survey (CDFW) • salvage at the federal and state Delta pumping facilities (BOR;DWR)	• Bay Study (Delta; CDFW) • salvage at the federal and state Delta pumping facilities (BOR;DWR)	• Sturgeon Study (trammel netting in Bay), Sturgeon Fishing Report Cards, boat logs, creel surveys (CDFW) • salvage at the federal and state Delta pumping facilities (BOR;DWR)	• Sturgeon Study (post-spawn), Sturgeon Fishing Report Cards, creel surveys (CDFW) • Yolo Bypass and Knights Landing fyke traps (DWR; CDFW) • stranding at Fremont and Tisdale weirs (DWR;CDFW) • gill and trammel netting in San Joaquin River spawning areas (USFWS)
Tissue analyses	• development (spawn timing; UCD) • preliminary genetic analysis of eggs (UCD; Cramer Fish Sciences)	• development analysis of larvae (spawn timing; UCD; BOR)	• juvenile age at length (CDFW)	• fin ray analysis from Sturgeon Study (age and growth), tissue analysis from fishing derbies (age and contaminants), preliminary fin microchemistry analysis (USFWS)	• fin ray, reproductive condition, and genetic analysis of sturgeon captured in San Joaquin River spawning habitat (USFWS;UCD)
Telemetry			• lower Sacramento River monitoring (primarily gill-netting) for acoustic tag implantation (CDFW;UCD)	• detection of previously tagged fish in existing array (DWR;UCD)	• tagging of adults from fykes, bypass stranding, and San Joaquin River spawning habitat and detection of current and previously tagged adults in acoustic array (DWR;USFWS;UCD)
Population modeling and synthesis			• ongoing analysis of YCI and hind-cast relative brood year abundance (CDFW)	• ongoing estimates of harvest and adult abundance with Sturgeon Study and Sturgeon Fishing Report Card data (CDFW)	• analyses of recapture rates of externally tagged sturgeon in spawning habitat (CDFW)

3. Sturgeon model framework





Spawning Adults

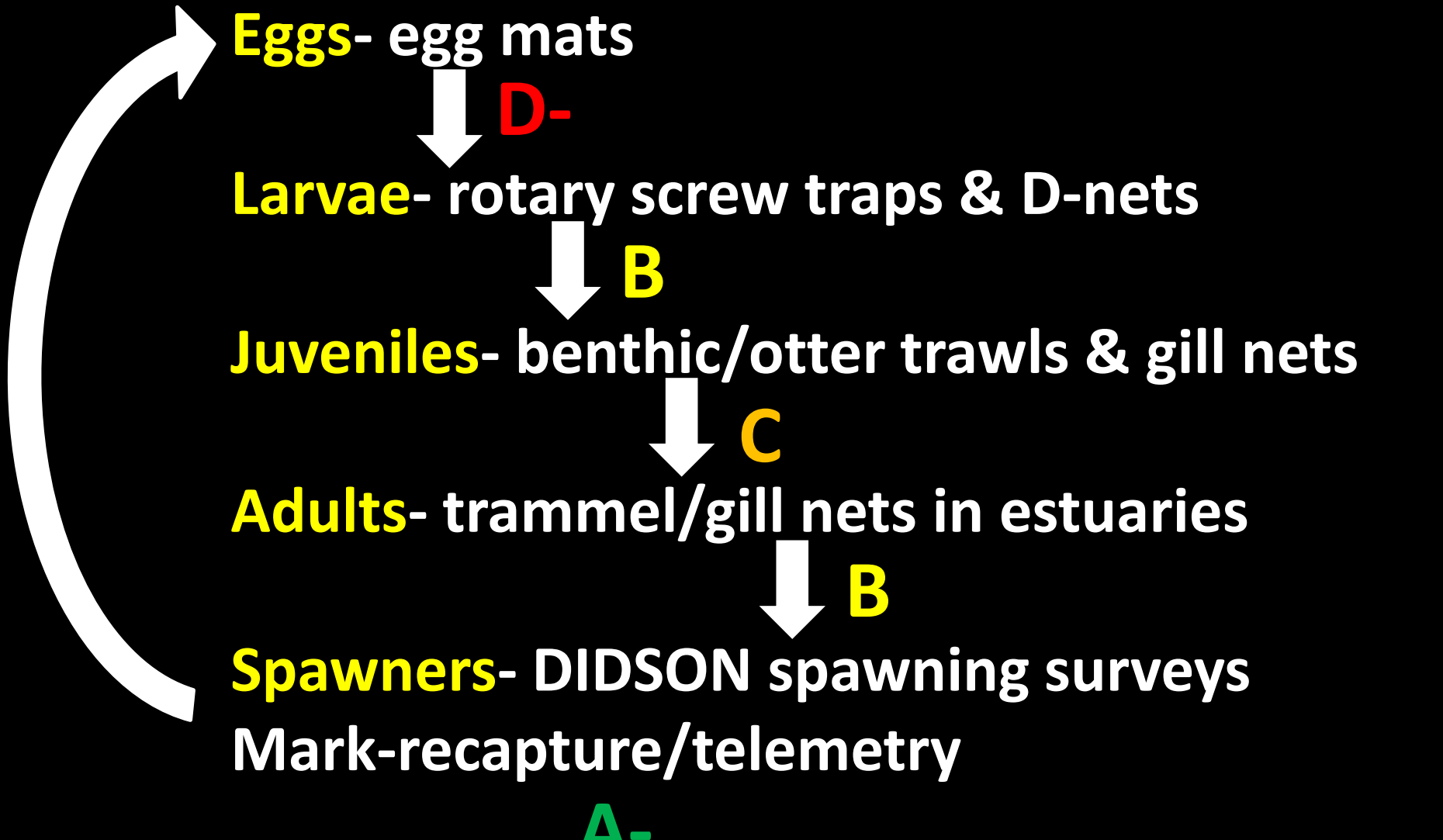
Eggs

Larvae

Subadults /Adults

Juveniles

4. Recommendation: Life stage surveys



4. Recommendation: Tissue analyses

- Genetic parentage and relatedness

Photo L. Heironimus USFWS

- Age and life-history from pectoral fin rays

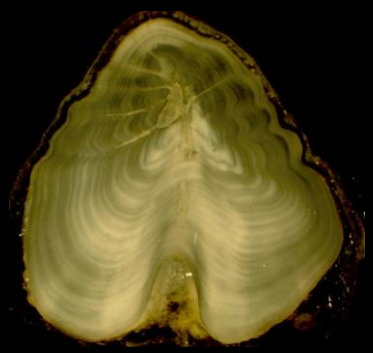


Photo Z. Jackson USFWS

Bins (cm TL)	White Sturgeon Ages									
	7	8	9	10	11	12	13	14	15	16
96-100	0.2568	0.3108	0.2838	0.0811	0.0135	0	0	0	0	0
101-105	0.2281	0.1842	0.307	0.1579	0.0702	0	0	0	0	0
106-110	0.0571	0.2143	0.3	0.2429	0.1	0.0286	0.0286	0	0	0
111-115	0	0.1186	0.3051	0.4237	0.1017	0.0169	0.0339	0	0	0
116-120	0	0.1136	0.1818	0.1818	0.1591	0.1591	0.0455	0.0909	0.0455	0.0227
121-125	0	0	0.0833	0.1111	0.1944	0.1389	0.1389	0.1389	0.1667	0.0278
126-130	0	0	0.0541	0.0811	0.2162	0.1351	0.0541	0.1622	0.0541	0.0811
131-135	0	0	0	0.0882	0.1176	0.1471	0.1176	0.0294	0.1176	0.1471
136-140	0	0	0	0	0	0.1154	0	0.2308	0.1538	0.2308
141-145	0	0	0	0	0	0.0286	0.0571	0.1429	0.1429	0.2286
146-150	0	0	0	0	0	0.027	0.1081	0.1622	0.1622	0.1351
151-155	0	0	0	0	0	0	0.0435	0.1304	0.087	0.087
156-160	0	0	0	0	0	0	0	0.0769	0.0769	0.1538
161-165	0	0	0	0	0	0	0	0	0	0.25
166-170	0	0	0	0	0	0	0	0	0	0.125
171-175	0	0	0	0	0	0	0	0	0	0.125
176-180	0	0	0	0	0	0	0	0	0	0
181-185	0	0	0	0	0	0	0	0	0	0
>185	0	0	0	0	0	0	0	0	0	0

4. Recommendation: Telemetry

- River and estuarine migration of juveniles
- Distribution and survival of adults and subadults
- *Long-term support of acoustic array including maintenance of an accessible detection database

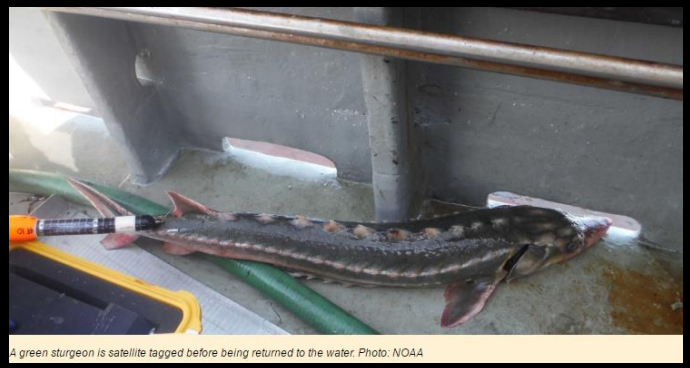
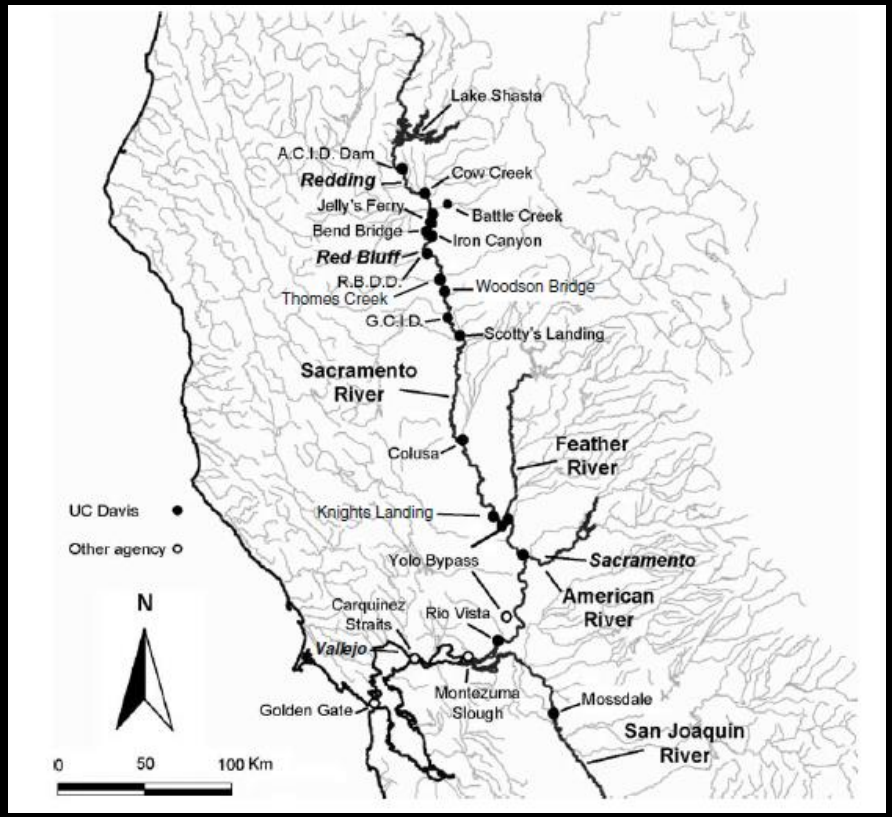


Photo NOAA



4. Recommendation: Population modeling & synthesis

- Development and technical review of juvenile recruitment indices

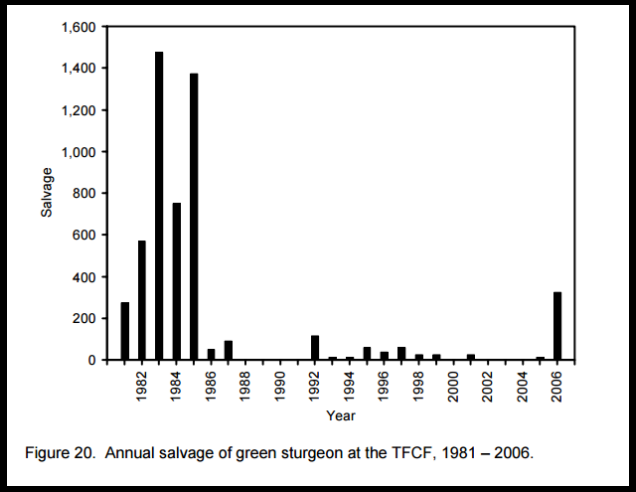
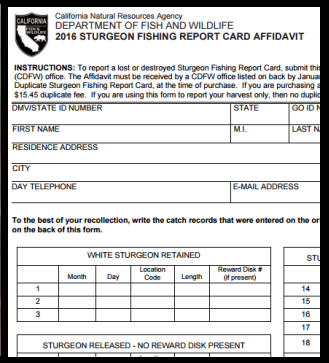


Figure 20. Annual salvage of green sturgeon at the TFCF, 1981 – 2006.

Figure Gartz 2007

- Improvement of abundance and harvest modelling techniques



California Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
2016 STURGEON FISHING REPORT CARD AFFIDAVIT

INSTRUCTIONS: To report a lost or destroyed Sturgeon Fishing Report Card, submit this
(CDFW) office. The Affidavit must be received by a CDFW office listed on back by Janua
Duplicate Sturgeon Fishing Report Card, at the time of purchase. If you are purchasing a
$15.45 duplicate fee. If you are using this form to report your harvest only, then no duplic

DMV/STATE ID NUMBER | STATE | GO ID N
FIRST NAME | M.I. | LAST N
RESIDENCE ADDRESS
CITY
DAY TELEPHONE | E-MAIL ADDRESS

To the best of your recollection, write the catch records that were entered on the or
on the back of this form.

WHITE STURGEON RETAINED					
	Month	Day	Location Code	Length	Reward Disk # (if present)
1					
2					
3					

STURGEON RELEASED - NO REWARD DISK PRESENT

Photo CDFW

- Multi-state synthesis estimates of abundance for green sturgeon

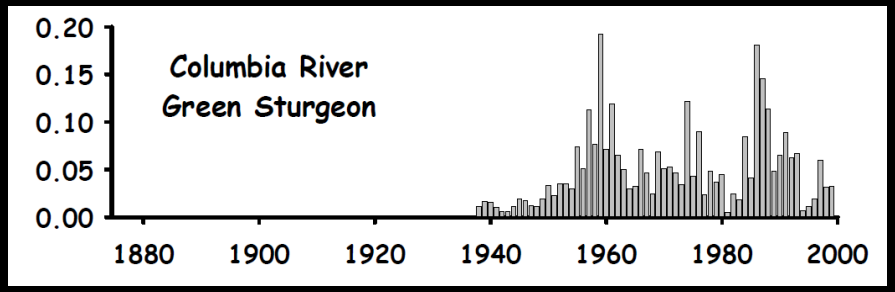


Figure Beamesderfer et al. 2005

Opportunities in the San Francisco Bay-Delta

- Recruitment indices for juvenile sturgeon- IEP/CDFW Bay Study, salvage
- Marking, acoustic tagging, and tissue analysis- IEP/CDFW Sturgeon Study, fyke traps, rescue and relocation, pilot juvenile gillnet surveys
- Synthesizing environmental conditions, operations, and cohort trends- Sturgeon Study, commercial passenger vessel boat logs, tag returns and report cards, salvage, 20mm Survey, Bay Study

Sturgeon recap

1. Management questions- answers to almost all questions rely to a degree on life-stage surveys
2. Monitoring inventory- monitoring inventories are necessary to establish context and feasibility for testing hypotheses/questions
3. Conceptual models- conceptual models provide a framework for illustrating and organizing recommendations to address these hypotheses
4. Recommendations- monitoring alone will not produce a single sturgeon but effective monitoring may inform management decisions that have population-level effects

Lessons Learned and Key Considerations

including

1. "Delta" vs. "Sierra-to-^the-Sea"
   - Status and trend monitoring at appropriate scales for adaptive management across fragmented regulatory authorities & landscapes
2. "Compliance monitoring" and new regulatory horizons
   - SWRCB's Water Quality Control Plan update, WaterFix, EcoRestore, SWP/CVP re-consultation, life cycle models (salmon and smelt) data needs
3. Framework & ecosystem performance indicators
   - Emerging science & evolving technologies
   - Summary of existing monitoring…helpful; rolling up sleeves offering key advancements…priceless

Questions?

US ARMY CORPS OF ENGINEERS

DELTA STEWARDSHIP COUNCIL